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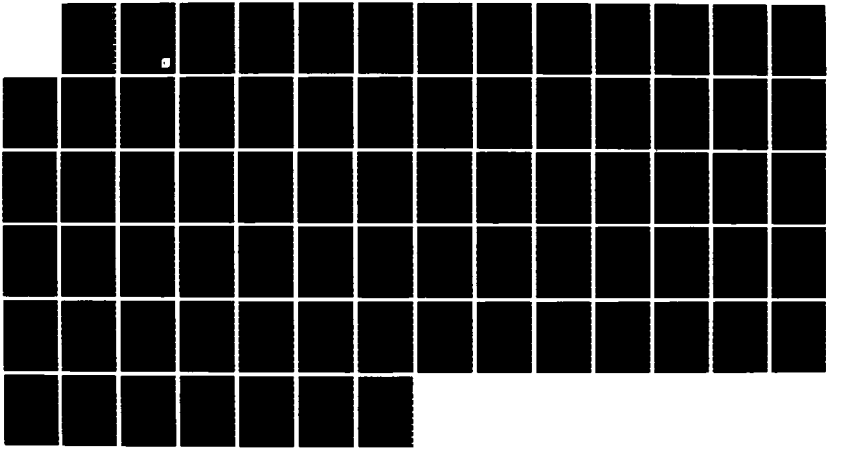

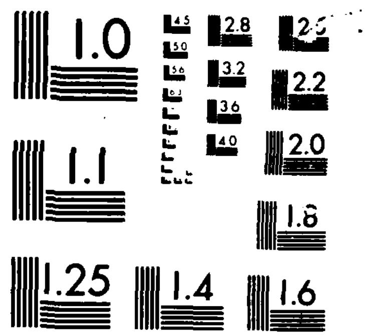
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IDA PAPER P-1882

C^3 EVAL MODEL DEVELOPMENT AND TEST

Volume III: Briefing

Robert F. Robinson
Joseph W. Stahl
M. L. Roberson
Applications Research Corporation

October 1985

Prepared for
Joint Chiefs of Staff

INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311

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This paper has been reviewed by IDA to assure that it meets high standards of thoroughness, objectivity, and sound analytical methodology and that the conclusions stem from the methodology.

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This is an interim report on the extension and development of the C^3 EVAL model. The model is to permit assessment of the effects on combat of changes in command and control processes and communications network structure and capacity. The model has had a partial pre-processor added to assist possible analyst/model users in input data and a post-processor to provide graphic display of some outputs. The command structure includes the Central European command nodes from division to SHAPE for U.S. forces. The nodes have had input and output links added to permit representation of degraded operation as under attack or when the unit is moving. The corps level force allocation procedure has been improved. Some processes have been randomized. The corps operates on information different from that available at the division or combat unit due to time delays, randomness, and scenario inputs. The impact of changes in the C^3 system can be seen in changes in weapon losses, non-arrival of close air support, and messages delayed/lost as well as other operations related elements.

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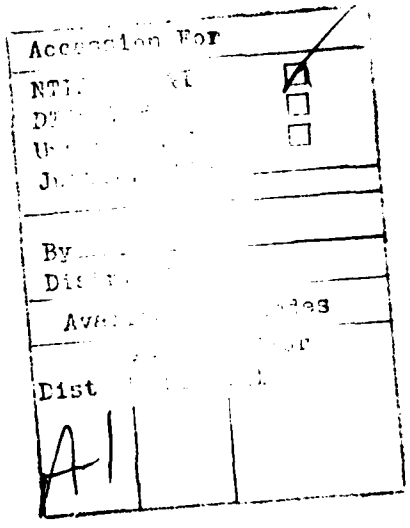

October 1985

INSTITUTE FOR DEFENSE ANALYSES

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PREFACE

This effort was undertaken in March 1985 as a part of a continuing program to develop the C3EVAL model as an analytic tool for use by the Office of the Joint Chiefs of Staff/Command Control and Communications Systems (OJCS/C3S) under Contract No. MDA 903-84C-0031, Task Order No. T-5-309. The basic model has been developed by IDA with programming support from Applications Research Corporation (ARC). This work is reported in IDA Paper P-1756, "Development of C3 Assessment Methodology: The C3EVAL Model," dtd February 1984. This is a report on work in progress and provides a description of the work done in FY1985, an update of the users' manual, and a briefing on the model and its current capabilities.

This briefing is a report on the status of the development of the C3EVAL model. The work has been done for JCS/C3S. The briefing is unclassified.

C³EVAL MODEL

DEVELOPMENT AND TEST

SEPTEMBER 1985

The briefing will first give a statement of the purpose or objectives and the criteria that determined the design of the model. A description of how the model operates and its current capabilities is followed by a brief description of the work being done on an input-preprocessor and a number of demonstrations of model operation and results.

OUTLINE

PURPOSE

CRITERIA

MODEL DESCRIPTION/ANALYSIS METHOD

DEMONSTRATIONS

- INPUT PRE-PROCESSOR
- C^3 SYSTEM FULLY OPERATIONAL
- V CORPS TAC NODE LIMITED OPERATIONS

OBJECTIVES

The objective of the effort undertaken in FY 1985 has been to extend the C3EVAL model. The basic program of the model had been developed and needed extension to be applicable to particular problems identified by JCS/C3S. The philosophy followed in the concept formulation and development was that:

- There should be a direct connection between the C3 processes and operations;
- The model should be aggregated for JCS level analyses and adaptable to a variety of C3 structures; and
- The model should be usable by a small team.

Since the basic structure existed and had been demonstrated, the intent in FY 1985 was to extend the C3 hierarchy from division to AFCENT or SHAPE for the V corps area and up. The rules and processes included those functions required for operations and intelligence and for interaction of ground operations with the Air Force.

- **OBJECTIVE**

  EXTEND THE MODEL SO THAT IT MAY BE USED TO DISPLAY THE COMBAT CONSEQUENCES OF CHANGES IN COMMAND AND CONTROL PROCESSES AND CHANGES IN COMMUNICATIONS NETWORK STRUCTURE AND CAPACITY. . . . .

  EMPHASIS IS ON EFFECTS OF CHANGES IN PLAN

MODEL CRITERIA

The fundamental requirement in this development of an analytic technique is to provide a means by which C^3 assessment could be measured in terms of operational effects. The basis of the means developed is the flow of information through explicit messages as specified in the doctrine of the organization being represented and the use of information to affect the operations of the military force. In this way C^3 affects combat and combat affects C^3. The assessment of C^3 is to provide the means to measure deficiencies in C^3 systems and to provide support to the Total Force Capability Assessment (TFCA) in a form that some of the effects of C^3 on the TFCA games can be measured. The model must be flexible in the sense that it should be applicable to a variety of organizational structures (Army, Navy, Air Force and Joint) with different scenario situations. It must also be possible to get a quick turnaround for the cases run. Finally, the model must be such that it can be easily used by the Joint Staff.

MODEL CRITERIA

- FLOW AND USE OF INFORMATION
- C^3 AFFECTS COMBAT
- COMBAT AFFECTS C^3
- ASSESSES C^3
  - C^3 DEFICIENCIES
  - TFCA SUPPORT
- FLEXIBLE AND QUICK TURNAROUND
- USABLE IN JCS

ANALYSIS METHOD--MODEL CHARACTERISTICS

The basic model is designed such that the number and arrangement of nodes or command posts are established by the user. The number and kinds of communications links or paths connecting the nodes are also user designated. The time interval of operation is selected. It is currently chosen to be representative of half an hour. (There is a lower limit on the length of the time interval modeled, and the upper length will be determined by the processes that are being modeled.) The time interval affects the decision rules that are inserted in the data that represent the command and control processes. The development and insertion of the decision rules for the nodes into the data structure is the most complex part of the model use. Nodes and paths and path capacity may exist or vary in capacity as a function of the time interval.

In the construction of the model there are a number of inherent assumptions. First, the model is driven by a pre-scripted scenario. This means that the user* will have to provide a time sequence of inputs that correspond to scenario events such as the arrival of additional friendly or enemy forces, electronic warfare events or others. There are eleven classes of weapons currently represented in the combat calculation. Classes include tanks, armored fighting vehicles, artillery and close air support aircraft. Two air missions are included and more could be easily added. At present only one air mission, CAS/BAI, is being used. One of the two data items programmed into the model is that if a message cannot be sent through the specified route, e.g., direct from division to corps main, two alternate routes will be tried, such as from division to division to corps main. The second data item is that when one mode or type of communication path has been tried and found unavailable, two other types may be tried, i.e., secure voice might have teletype as an alternate. The assumption of two was based on the time available in a message center and seemed in agreement with operational experience. This procedure is available for each message in each time interval. As indicated, the current time interval is half an hour, with the process recycling each 24 hours.

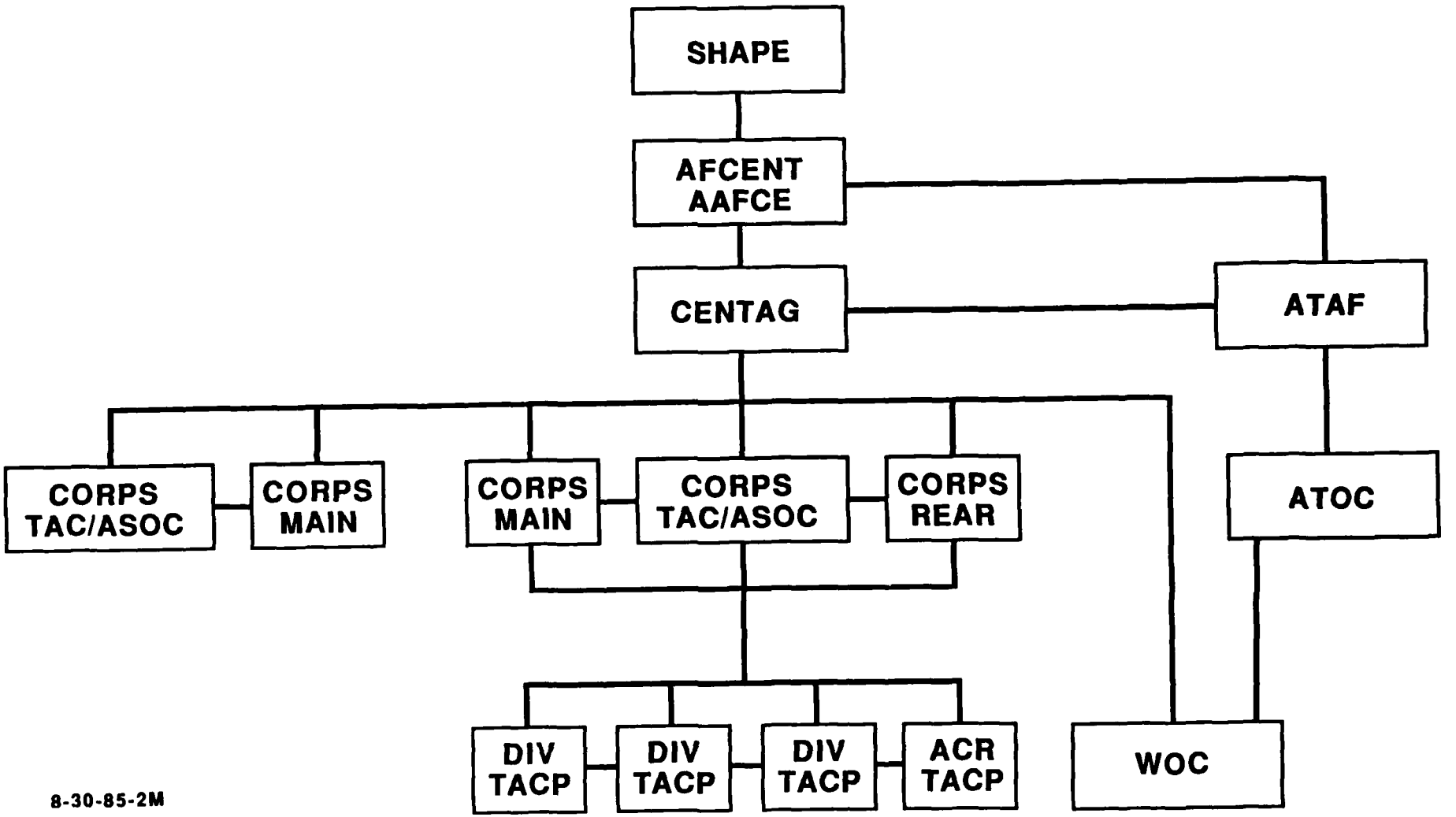
*User - The analyst applying the system to problems.

ANALYSIS METHOD - MODEL CHARACTERISTICS

- CAPABILITIES
  - Number of nodes and paths user designated by time interval
  - Node capability by input decision rules
  - Path capacity input by user by time interval

- ASSUMPTIONS
  - Pre-scripted scenario driven
  - 11 classes of ground weapons
  - Two air missions
  - Two alternate routes for messages
  - Two alternate path types for messages
  - 24 hour cycle, half hour time intervals

The nodes or representations currently available in the model are those shown. Only a single generalized path is shown connecting the nodes. Within the corps, the Air Force Air Support Operations Center (ASOC) and the division Tactical Air Control Party (TACP) are combined in the node with the appropriate ground force unit. This arrangement represents the co-location of the air force unit with the ground force unit. An important feature to be noted here is that any unit, once created, will be assigned a number, and all units with the same number will operate with the same decision rules. A division, for example, is designated as 300, and all divisions so numbered will operate with the same rules. If a division is introduced that operates according to a different doctrine and hence a different rule system, it must be assigned a different number. For example, if the German III Corps is included, its divisions should be assigned a 320 or some other number.


SHAPE
AFCENT
AAFCE
CENTAG
ATAF
CORPS
TAC/ASOC
CORPS
MAIN
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MAIN
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TAC/ASOC
CORPS
REAR
ATOC
DIV
TACP
DIV
TACP
DIV
TACP
ACR
TACP
WOC

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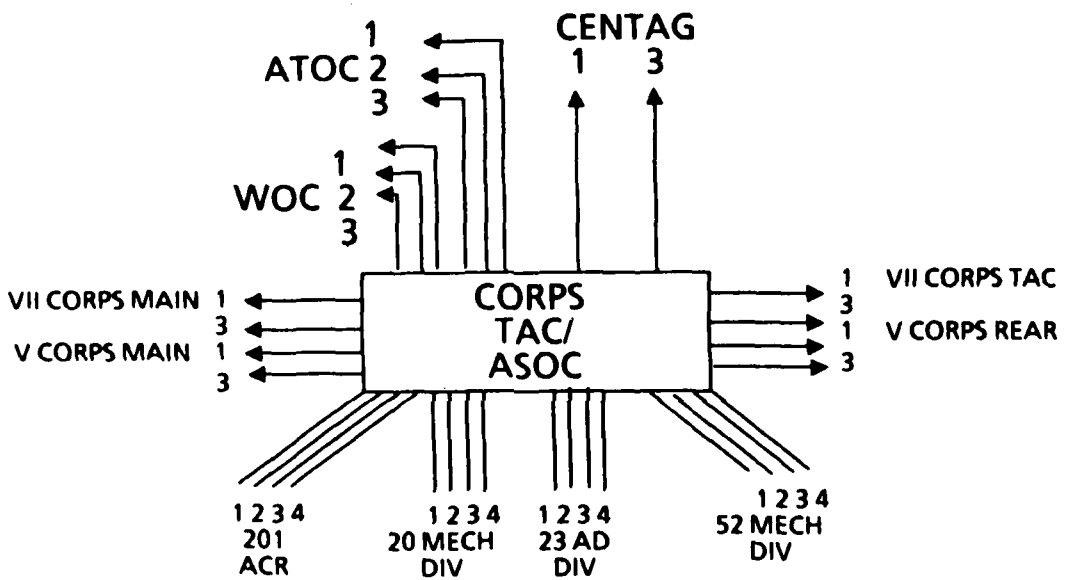
In order to illustrate the paths that can exist from a node, an example is shown from the current model. The Corps Tac has 32 paths representing four different types of communications connections with 10 other command nodes. This includes the Air Force ASOC paths. There could be additional paths and types added if the model user so chose. The capacities of the paths are established by the number of characters sent in one-half hour. Doctrine can indicate some features of usage. U.S. Army documents indicate, for example, that when a multi-channel link with 12 channels is available, typically 10 will be for voice and two for teletype. It should be noted that when a high-capacity link is available, such as a 24 kb link that is used for voice, the usable capacity is 9,000 characters in a half-hour time period, since this is a high rate of information flow for voice. If data links, indicated "3" in the illustration, are used, then a much greater proportion of the capacity can be used. The representation of courier is by a very large capacity path.

EXAMPLE OF COMMUNICATIONS PATHS FROM A NODE



1 SECURE VOICE

2 VOICE

3 DATA

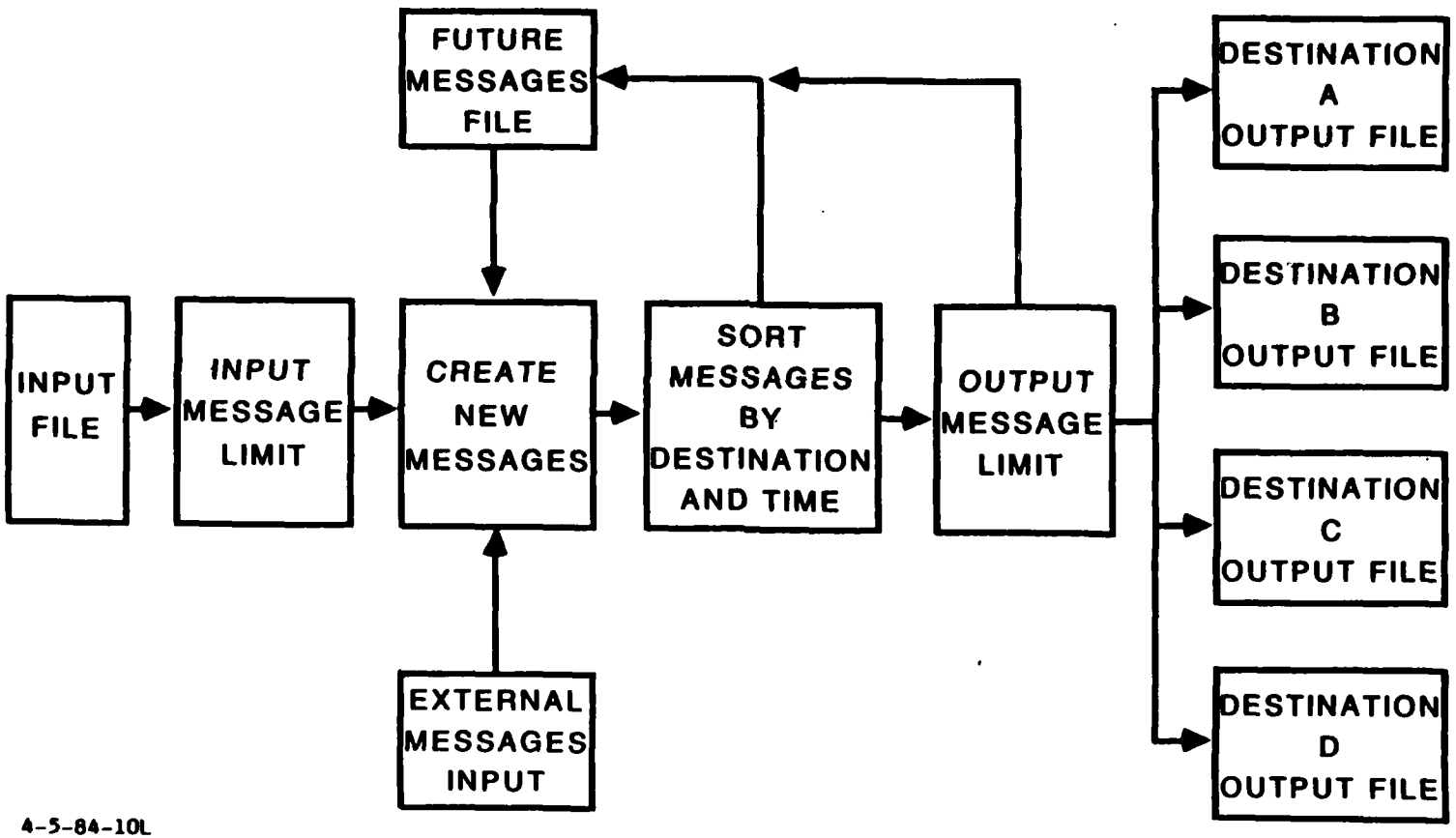
4 COURIER

ANALYSIS METHOD--NODE STRUCTURE

The operation of the nodes is central to the C³EVAL model. This slide shows the major parts of the node internal structure. Each node has a similar structure that checks to see that messages are assembled according to the rules that designate priorities, destinations, transmission modes and message content. Each node can be designated as belonging to a generic type, i.e., division main command post, Air Tactical Operations Center (ATOC) or other. Each node has three files on the input side that may contain messages. The messages in these input files are the file of messages from other nodes (units), the file of messages input by the user (external file) or from the Time T data and the file of messages to be sent at a future time. The first process to which messages are subjected may be the input message limit. This is to represent a limitation on the capability of the node to receive messages as when the unit is on the move. The limitation is designed to pass priority one messages and a specified number of lower priority messages. The input file messages are sorted as they come in, the external and future file messages are sorted by time. Messages can be sent to the future file for several reasons. The first is that the capacity of the communications paths on which the message could be sent was exceeded before that particular message got there and the messages could not be sent during that time period. A second is that the message may require more than one time period to assemble after all the input messages have been received. Specified messages may be held for a period of time determined by a random draw. At division, message length may also be determined by random draw. Based on the messages received, new messages may be created. Messages that cannot be sent due to output message limits may also be sent to the future file. The new messages may be put in the future file or they may be sent in the same time period, depending on the decision rules that indicate the number of time intervals required to generate the messages. The output limitation is to represent limits on the capability of the command node to generate messages. This could be the result of bombing of the headquarters, movement or other activities. The output limits restrict the numbers of messages by priority.

Messages that are to be sent within the current time interval are moved to a destination file. Each unit has a destination file for each unit that it may communicate with during the run. The first step in the process is the determination of how messages will be sent. This is done by comparing the capacity required by all messages to be sent on their primary transmission path with the total capacity of the path. Capacity is determined by the messages measured in terms of the number of characters that can be sent during the time interval. Capacity can be determined by the physical properties of the path, as with TTY, or by a standard capability such as the number of characters that can be transmitted as by voice. When the required capacities are insufficient, the priorities of the messages are compared. Those messages that cannot be sent are bumped to the alternate communication types, on which the same process is followed. If the messages still cannot be sent, the messages in the hold queues are assessed to determine if they can be sent through alternative destinations where they would be forwarded. If this is done, the message is flagged so it can be traced. The flag also tells the alternate destination not to do anything to the message except to try to send it on to its original destination. When all this is completed, the process is repeated. This is to cover the possibility that if a message assigned to its first alternate destination is bumped by a message that is being re-routed, it is checked for its alternative routing.

ANALYSIS METHOD – NODE STRUCTURE



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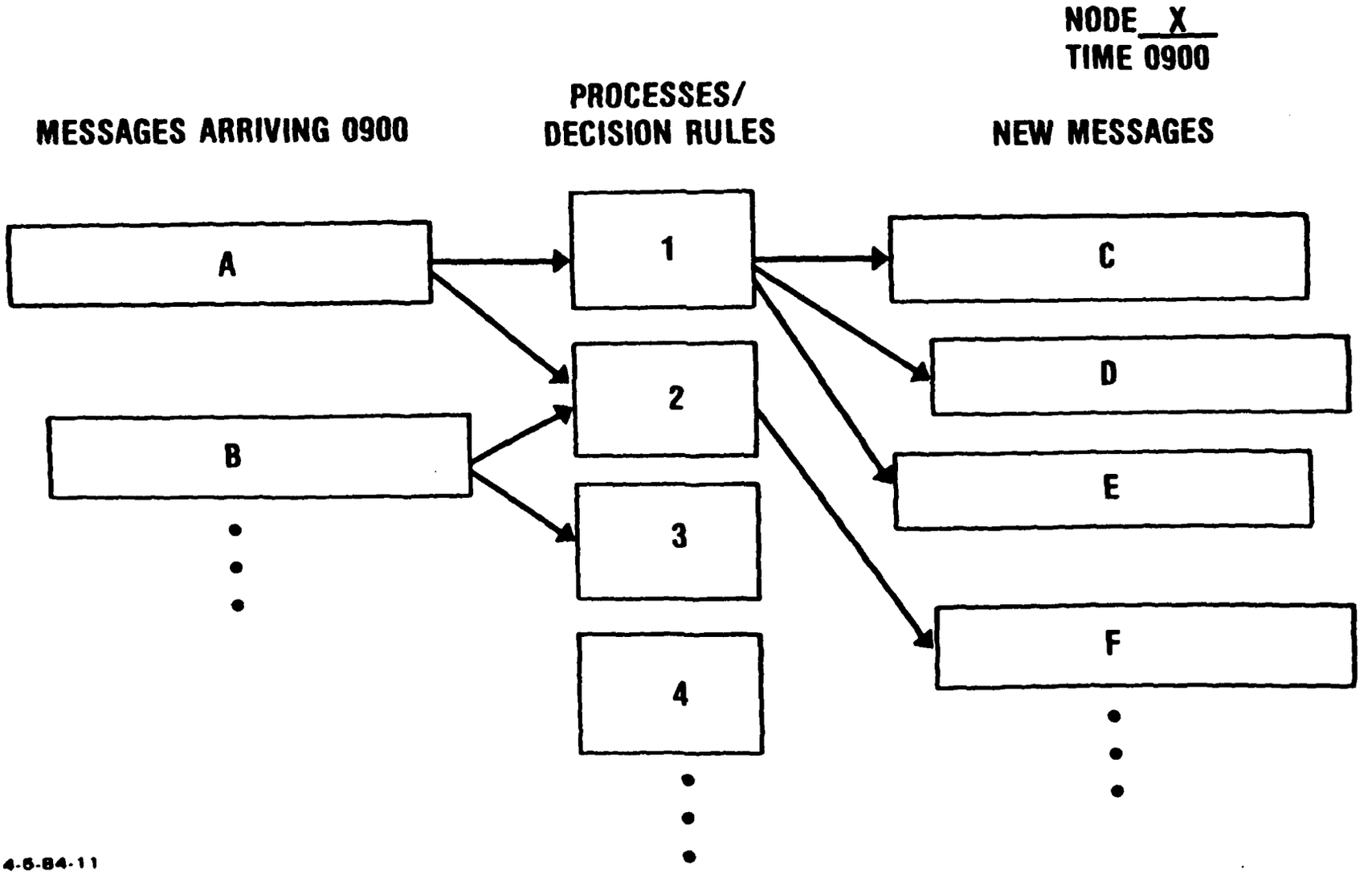
ANALYSIS METHOD--MESSAGE GENERATION

During a time interval a unit or node may "create" messages according to decision rules. The basis for the rules is either the occurrence of an event or the passage of time. An event may be the arrival of a message(s) or a combat or intelligence event from the scenario. The passage of time means that there may be specific periodic reports required at definite time intervals. In the examples shown, Arriving Messages A and B are combined in Process 2 to produce Message F. Process 2 may be a simple combination of input messages that are of less than a specified age or the process may require an assessment, for example, of the availability of needed resources. Rules may be applied that compare, for example, the relative need of subordinate units. The data required for the process includes information concerning how often the process is performed, which input messages are required, and the age and content of those messages. The specifications for the output messages that are generated by the completion of the processes include the content, destination, priority and the time at which the message is to be sent. The construction of the decision rules is the most complex of the input data development.

ANALYSIS METHOD — MESSAGE GENERATION



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One of the major additions in the work accomplished this year is the installation of rules for allocation of corps controlled combat resources. All three resources--artillery, Air Force CAS/BAI and attack helicopters--can be allocated to divisions by means of external messages. This means that a scenario input at a division will generate messages up through the system requesting resources. For Air Force controlled CAS/BAI, the requests will also go up through the tactical air net. The external input will also determine the allocation of all resources according to the plan for the day. Requests for CAS/BAI sorties can also be generated at division when the force ratio exceeds a user-specified value. When the request arrives at corps it is assessed in terms of the data at corps based on losses reported by the Blue division making the request and the attrition of the Red division, again as reported by the division. From this data, corps calculates a ratio of forces (enemy to friendly) and if that force ratio is greater than an other requesting division's estimated force ratio, the request is approved. The approved request moves from the ASOC to the ATOC and WOC where aircraft will be sent to support the division, depending on the availability of aircraft at the aggregated airbase.

Corps artillery and corps helicopters are assigned to the division according to plan by external message. Any re-allocation of those resources are managed within the division through re-allocation by posture change.

RULES FOR ALLOCATION OF CORPS COMBAT RESOURCES

	EXTERNAL INPUT	FORCE RATIO	COMBAT INTENSITY
ARTILLERY	X		X
CAS/BAI	X	X	
HELICOPTERS	X		X

FOR CAS/BAI

ALLOCATION BASED ON

- AVAILABILITY OF AIRCRAFT
- CORPS APPROVAL BASED ON INFORMATION AVAILABLE AT CORPS FROM DIVISION

ANALYSIS METHOD--ACTION MODELS

Air operations at the base are essentially represented by a queuing model in which aircraft are allocated by type to the queue.

The airbase model contains representations of a Wing Operations Center (WOC) and Control and Reporting Center (CRC). The WOC controls the allocation of available aircraft on the ground to the requests for air support that it has received via messages. The CRC receives control of sorties once they are airborne. The CRC process calculates the time over target, modifies the appropriate unit combat matrix to include the sorties, calculates attrition to the enroute aircraft, and schedules them for control by the WOC after they land. Only one mission is flown in the present configuration, close air support (CAS)/Battlefield Air Interdiction (BAI).

Attrition of aircraft can occur on the way to the battle or in the battle area. It occurs only due to ground-to-air fires. The pre-planned sortie schedule is input by external message. Requests are indicated by force ratio thresholds.

ANALYSIS METHOD - ACTION MODELS

AIR OPERATIONS

QUEUEING MODEL

QUEUE BY AIRCRAFT TYPE

TWO MISSIONS

- CAS/BAI
- OTHER

CAS/BAI ATTRITION

FIGHTS LAUNCHED

- ACCORDING TO PRE-PLANNED SORTIE SCHEDULE
- BY REQUEST FROM AIRCRAFT AVAILABLE DURING TIME SEGMENT

ANALYSIS METHOD--ACTION MODELS

The "Action Models" are to represent aspects of the military combat and support operations which affect the C^3 system and which are affected by that system. The representation of the ground force engagement processes that are included in the current version of the model uses a matrix method of calculation of the attrition processes. This method is similar to that used in the dynamic model used in the TFCA games. The matrix method allows for the calculation of attrition by fires of N Blue weapons on M Red weapons with allocation of fire and engagement rates according to input data. The kill probabilities are also specified. Since these matrix coefficients can be changed by directive, a change can be introduced by the arrival of a message or a change of posture as specified by a scenario event. Changes in the number of weapons available could also cause the initiation of a message as, for example, when the force ratio reaches a certain level a request is made for supplemental close air support.

ANALYSIS METHOD - ACTION MODELS

GROUND FORCE MODEL

MATRIX METHOD FOR ATTRITION CALCULATION

- ESSENTIALLY THE INBATIM/IDAGAM METHOD
- CALCULATION ACCOUNTS FOR:
  - NUMBER OF WEAPONS BY TYPE
  - PROBABILITY OF KILL
  - ENGAGEMENT RATE
- C^3 OR INPUT DETERMINES:
  - WEAPONS PRESENT
  - POSTURE

During the process of adding rule systems and data, a preliminary step was made to add random processes to represent better the operation of a command and control system. Randomness in division message length and message start time have been mentioned previously. Since the model has been designed so that the information available at corps concerning the strength of Blue and Red forces will be different from that at division, a random process was introduced that affects the Red and Blue loss reports. This introduces another effect into the decision process. A randomness is also available to cause CAS requests by division that are initiated by a trigger force ratio to be delayed. Currently the random draw comes from a uniform distribution. If other distributions are desired, they can be installed with little difficulty.

RANDOM PROCESS

- PERCEPTION OF LOSSES REPORTED TO CORPS TAC BY DIVISION, EACH SIDE, PER MESSAGE
- AT DIVISION LEVEL MESSAGES MAY HAVE THE MESSAGE LENGTH CHANGED
- COMMAND POST MESSAGES HAVE START TIME PLUS A RANDOM LENGTH DELAY
- FORCE RATIO CAUSED CAS REQUESTS MAY BE DELAYED

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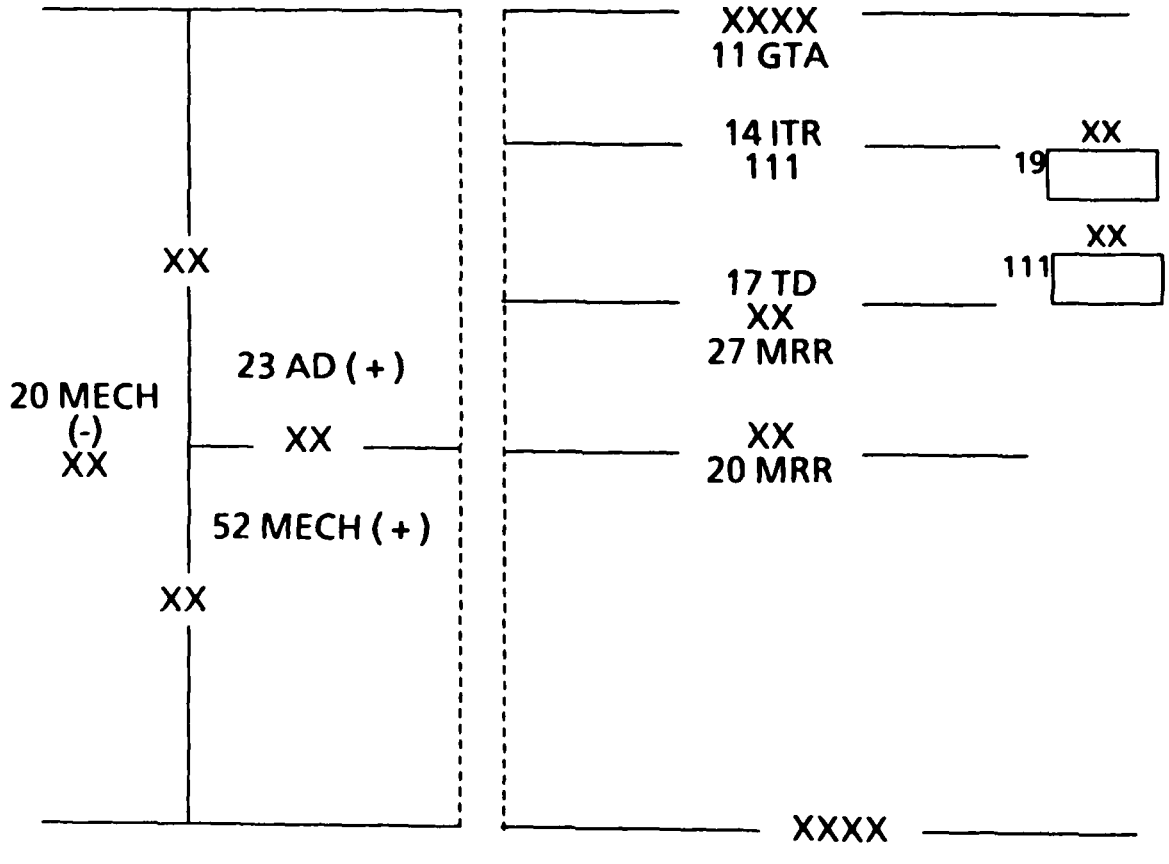
DEMONSTRATIONS

- SCENARIO
- INPUT PRE-PROCESSING
- BASE CASE

The scenario used is represented by the corps area shown. In the model it is designated the Vth Corps, although the divisions and forces used are ficticious and unclassified. There are two divisions on line, the 23rd Armored Division and the 52nd Mechanized, with the 20th Mechanized in reserve. They are being attacked by the Red forces shown. The units shown are ficticious ones.


XXXX
11 GTA
14 ITR
111
XX
19
XX
111
17 TD
XX
27 MRR
XX
20 MRR
XXXX
XX
23 AD (+)
20 MECH
(-)
XX
XX
52 MECH (+)
XX

The combat sequence used in the model starts with time interval one at 0600 on the second day of the war. The major events of the 24-hour day are indicated with the model time period. These events reflect major changes in the intensity of combat and are observable in the rate at which losses occur.

COMBAT SEQUENCE

Time	Period	
7:30	3	23 ARMOR & 52 MECH TAKE OVER COMBAT FROM 201 ACR
10:00	8	23 ARMOR REINFORCED BY BDE FROM 20TH MECH DIV
18:30	25	RED COMMITS 2ND ECH TANK DIVISION
22:30	33	23 ARM CHANGES POSTURE TO LOWER ENGAGEMENT RATE WHEN RED ALSO GOES TO HIGHER ENGAGEMENT RATE

The input pre-processor is intended to provide a "user-friendly" data input means for all users. The chart shows the menu of data inputs. At this time the first six items on the menu have been implemented. The pre-processor has been developed for use on the VAX 785 using the VAX software FMS (Form Management System).

MAIN MENU

1. EXIT
2. INSTRUCTIONS
3. PREAMBLE DOCUMENTATION
4. SIMULATION CONTROL
5. NODE DICTIONARY
6. NODE
7. LIMITS
8. COMMUNICATIONS NETWORKS
9. EXTERNAL MESSAGES
10. COMBAT DATA
11. AIRCRAFT DATA
12. HELICOPTER DATA
13. RULES

SELECT OPTION NUMBER (1-12):

MODE

1. CREATE
2. EDIT

SELECT MODE (1-2):

The second item on the menu is the instruction screen. This is shown on the slide. The instructions are presented in language and format appropriate to the VAX.

INSTRUCTION SCREEN

MOVING FROM ONE FIELD TO ANOTHER:
NEXT FIELD = <TAB>
PREVIOUS FIELD = <BACKSPACE> OR <BS>

SCROLLING IN A SCROLLED AREA:
SCROLL NEXT = DOWN_ARROW
SCROLL PREVIOUS = UP_ARROW
EXIT SCROLLED AREA NEXT = <PF1> DOWN_ARROW
EXIT SCROLLED AREA PREVIOUS = <PF1> UP_ARROW

SEARCHING FOR ENTRY = KEYPAD 4
NOTE: WHEN RESPONDING TO PROMPT HIT <ENTER> NOT <RETURN>

DELETING ENTRY = KEYPAD 6
NOTE: WHEN RESPONDING TO PROMPT HIT <ENTER> NOT <RETURN>

LOOKING AT ENTRIES:
NEXT SCREEN = KEYPAD 2
PREVIOUS SCREEN = KEYPAD 8

HIT <RETURN> TO RETURN TO MAIN MENU

This slide shows a sample of the input of data for a node. The first line is the name assigned to the node with the ID number assigned by the computer. The second line is the superior or commander to whom the node reports. Alternative destinations are listed below on lines 3 and 4. The next step is to list the subordinate units and the alternates for those units. The final listing is of other network nodes to which a connection is made. There is no requirement to provide each node with alternates. The subordinate and other network unit portions of the display are scrolled areas.

		ID
NODE NAME	V CORPS TAC	0001
COMMANDER	CENTAG	0002
ALTERNATE 1	V CORPS MAIN	0003
ALTERNATE 2	V CORPS REAR	0004

SUBORDINATES

UNIT	ID	ALTERNATE 1	ID	ALTERNATE 2	ID
52 MECH DIV	0005	201 ACR	0006	23 ARM DIV	0007
23 ARM DIV	0007	52 MECH DIV	0005	20 MECH DIV	0008
201 ACR	0006	52 MECH DIV	0005		

OTHER NETWORK NODES

UNIT	ID	ALTERNATE 1	ID	ALTERNATE 2	ID
7 CORPS MAIN	0009	7 CORPS TAC	0010		
7 CORPS TAC	0010	7 CORPS MAIN	0009		
WOC	0011	ATOC	0012		

MODE: EDIT HIT <RETURN> TO RETURN TO MAIN MENU

This slide shows the base case "ground truth" of the Blue and Red forces in the 23rd Armored Division area at the end of the 24 hours. Ground truth is the operating data for the combat units in the model. For this case there are no random events, all communications paths are fully available, and all command nodes are operating with no constraints on their operating capacity.

COMBAT STRENGTHS

UNIT 23 ARM DIV FORCE POSTURES BLUE 2 RED 2 TIME 48 R/

	BLUE 2	RED 2
APC	150.	118.
AFV	181.	276.
TANK	225.	474.
ATANK LT	246.	843.
ATANK HV	72.	1.
MORTAR	75.	27.
ARTILLERY	8.	510.
HELICOPTER	0.	27.
AAA	21.	31.
SAM	67.	421.
CAS	0.	0.

The perception at V Corp Tac of the Red forces engaging the 23rd Armored Division is considerably different from that at the division. There are two reasons for this. The first is that the scenario input data to Corps Tac specifying the compositions of Red units is the generic table of equipment for Red motorized rifle and tank units. The second is that even under the best of conditions the reports from division of attrition of Red units will be delayed one-half hour.

COMBAT PERCEPTIONS BY V CORPS TAC OF 23 ARM DIV AT TIME 48

POSTURE BLUE 2	FOE UNIT	TYPE	POSTURE	TIME		
	127 TH MRD	325	2	1		
	17 TH TD	225	2	1		
	111 TH TD	225	2	1		
UNIT APC					287	239
UNIT AFV					249	311
UNIT TANK					496	413
UNIT ATANK LT					818	232
UNIT ATANK HV					17	58
UNIT MORTAR					66	24
UNIT ARTILLERY					94	194
UNIT HELICOPTER					-75	75
UNIT AAA					46	2
UNIT SAM					311	4
UNIT CAS					-11	11

The table shown is a summary table of messages after 48 time intervals or one day. In this table the command nodes are listed in the first column, the command node number as designated in the model, and the third column is the type of unit. The convention followed to create the data set used is that three-digit numbers are used for ground force commands and four-digit numbers are used for air force commands. Divisions are thus designated with 300, Corp Tac as 450 and the WOC is 7,000. The program requires the WOC to be 7,000. The first four data columns of the table are the messages including diverted messages into the command node, out of the command node, those messages put on hold due to inability to send and those messages that were killed since they were held until the specified life of the message was exceeded. It can be seen that one message was killed at AFCENT/AAFCE. The next group of three columns are those that would tabulate the effects of an input limit on the ability of the command node to process messages excluding diverts and the third group of three is for the effects of the output limit also excluding diverts. Since there were neither input nor output limits, these columns merely repeat the first and second columns of the first group. In the fourth group the CAS and helicopter sorties are listed. For the base case there was a total of 24 sorties (flown in support of the 23 Arm. Div. during these 48 time intervals).

RANDOM OFF 9/4/85

SUMMARY OUTPUT AT TIME 48

UNIT	NUMBER	COMMUNICATIONS LIMIT TYPE	IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
SHAPE	18	700	10	1	0	0	10	0	0	1	0	0	0	0
AFCENT/AAFC	17	600	28	15	0	1	28	0	0	16	0	0	0	0
VII CORPS	16	400	7	2	0	0	7	0	0	2	0	0	0	0
VII CORP TA	15	450	5	5	0	0	5	0	0	5	0	0	0	0
CENTAG	14	500	19	14	0	0	19	0	0	14	0	0	0	0
V CORP REAR	13	490	19	0	0	0	19	0	0	0	0	0	0	0
V CORPS TAC	12	450	231	35	0	0	231	0	0	35	0	0	0	0
52 MECH	9	300	24	129	0	0	24	0	0	129	0	0	0	0
WOC	8	7000	5	11	0	0	5	0	0	11	0	0	0	0
ATOC	7	5000	13	21	0	0	13	0	0	21	0	0	0	0
4ATAF	6	6000	22	28	0	0	22	0	0	28	0	0	0	0
23 ARM DIV	4	300	32	124	0	0	32	0	0	124	0	0	24	0
V CORPS	3	400	30	12	0	0	30	0	0	12	0	0	0	0
20 MECH	2	300	23	38	0	0	23	0	0	38	0	0	0	0
201 ACR	1	250	8	5	0	0	8	0	0	5	0	0	0	0

In the second case the random events were turned on, and the external messages causing CAS/BAI sorties to arrive according to the preplanned schsedule were deleted. Instead, the force ratio trigger was set at division level so that CAS/BAI sorties would be requested whenever the force ratio exceeded the user-specified level. An examination of the message summary shows first that the number of messages being processed has increased greatly. This is exemplified by the change at Corps Tac from 231 messages in to 413 messages in and 35 messages out to 68 messages out. The increase in message traffic is due to the inclusion of a large number of randomly initiated messages that include queries, reports of EW events, reconnaissance reports from aircraft and other such messages that are all listed and traced individually in the more complete print-out. It should be noted in this case that the 23rd Armored Division is still receiving 24 CAS/BAI sorties.

RANDOM ON AND CAS GENERATED BY F/R 9/6/85

SUMMARY OUTPUT AT TIME 48

UNIT	NUMBER	COMMUNICATIONS LIMIT TYPE	IN	OUT	HOLD	KILL	INPUT LIMIT IN	HOLD	KILL	OUTPUT LIMIT OUT	HOLD	KILL	SORTIES CAS	HELO
SHAPE	18	700	46	13	0	0	46	0	0	13	0	0	0	0
AFCENT/AAFC	17	600	185	123	0	1	185	0	0	124	0	0	0	0
VII CORPS	16	400	7	2	0	0	7	0	0	2	0	0	0	0
VII CORP TA	15	450	33	5	0	0	33	0	0	5	0	0	0	0
CENTAG	14	500	99	68	0	0	99	0	0	68	0	0	0	0
V CORP REAR	13	490	34	32	0	0	34	0	0	32	0	0	0	0
V CORPS TAC	12	450	413	68	0	0	413	0	0	68	0	0	0	0
52 MECH	9	300	31	217	0	0	31	0	0	217	0	0	0	0
WOC	8	7000	9	102	0	0	9	0	0	102	0	0	0	0
ATOC	7	5000	98	208	0	0	98	0	0	208	0	0	0	0
4ATAF	6	6000	236	165	0	0	236	0	0	165	0	0	0	0
23 ARM DIV	4	300	36	204	0	0	36	0	0	204	0	0	24	0
V CORPS	3	400	139	60	0	0	139	0	0	60	0	0	0	0
20 MECH	2	300	30	126	0	0	30	0	0	126	0	0	0	0
201 ACR	1	250	8	5	0	0	8	0	0	5	0	0	0	0

Comparison of the Corps Tac perceptions of the Red forces shows a change. The number of tanks reported killed has, for example, changed from 413 in the base case to 390 in the present case. This is due to the change in the arrival time of the CAS/BAI sorties and the random error in the losses reported by the division.

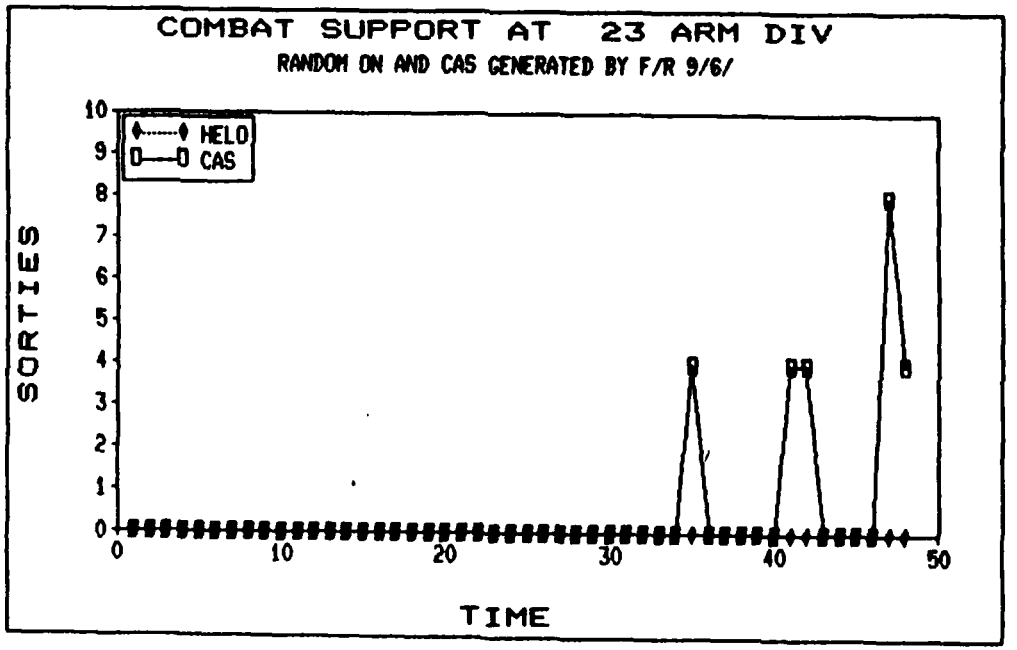
COMBAT PERCEPTIONS BY V CORPS TAC OF 23 ARM DIV AT TIME 48

POSTURE BLUE 2

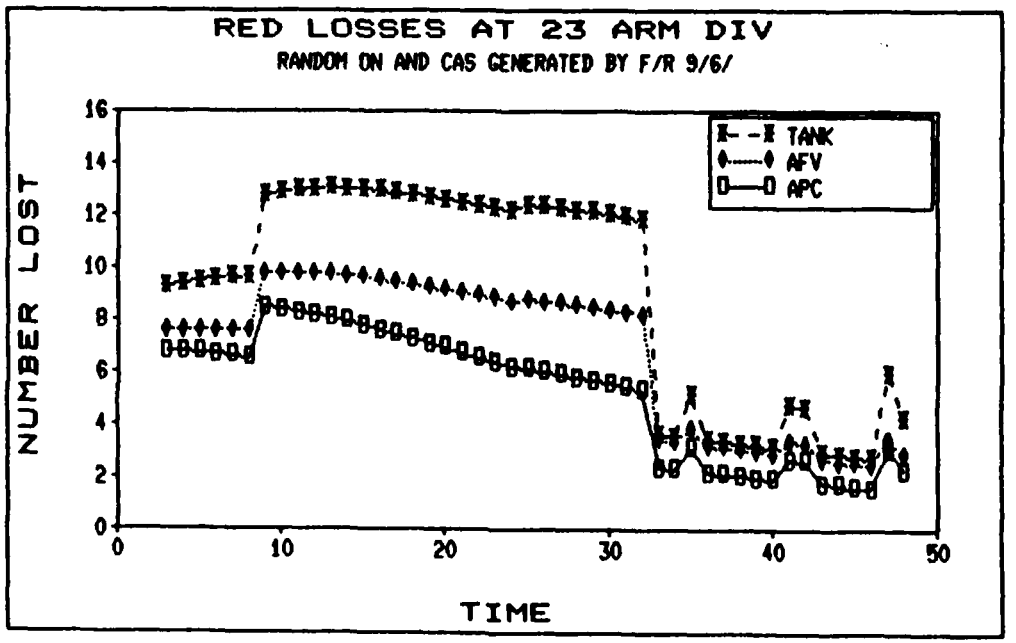
FOE UNIT	TYPE	POSTURE	TIME
127 TH MRD	325	2	1
17 TH TD	225	2	1
111 TH TD	225	2	1

UNIT APC	300	226
UNIT AFV	267	293
UNIT TANK	519	390
UNIT ATANK LT	832	218
UNIT ATANK HV	18	57
UNIT MORTAR	67	23
UNIT ARTILLERY	104	184
UNIT HELICOPTER	-70	70
UNIT AAA	46	2
UNIT SAM	312	3
UNIT CAS	-11	11

Under the assumptions of this case with the request for CAS/BAI sorties generated by the force ratio trigger, the sorties now appear later in the day.


COMBAT SUPPORT AT 23 ARM DIV
RANDOM ON AND CAS GENERATED BY F/R 9/6/
HELO
CAS
SORTIES
TIME
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50

The impact on the Red forces is as shown in the illustration.


RED LOSSES AT 23 ARM DIV
RANDOM ON AND CAS GENERATED BY F/R 9/6/
NUMBER LOST
TIME
TANK
AFV
APC
0
2
4
6
8
10
12
14
16
0
10
20
30
40
50

In this case the major alteration is that Corps Tac is out of operation between time interval 4 and time interval 20. The random switch is on and otherwise all communication paths are fully available and requests for CAS/BAI sorties is by external message or it corresponds with the pre-planned sortie schedule shown in the first case. The Corps Tac is sent 422 messages; however, 388 are accepted and 34 are killed due to the fact that some sent during the time that corps Tac was shut down exceeded the age limit. Also during this period the output of messages was also reduced so that the Corps Tac output during the 48 time intervals dropped to 48 messages, with 15 output messages being lost. Also, note that in this case the number of CAS/BAI sorties dropped to 12.

RANDOM ON PLUS CORP TAC DESTROYED TIME 4 - 20 9/4/85

SUMMARY OUTPUT AT TIME 48

			COMMUNICATIONS LIMIT				INPUT LIMIT			OUTPUT LIMIT			SORTIES	
UNIT	NUMBER	TYPE	IN	OUT	HOLD	KILL	IN	HOLD	KILL	OUT	HOLD	KILL	CAS	HELO
SHAPE	18	700	38	15	0	0	38	0	0	15	0	0	0	0
AFCENT/AAFC	17	600	193	118	0	1	193	0	0	119	0	0	0	0
VII CORPS	16	400	5	2	0	0	5	0	0	2	0	0	0	0
VII CORP TA	15	450	29	5	0	0	29	0	0	5	0	0	0	0
CENTAG	14	500	96	58	0	0	96	0	0	58	0	0	0	0
V CORP REAR	13	490	35	36	0	0	35	0	0	36	0	0	0	0
V CORPS TAC	12	450	422	46	0	0	388	0	34	46	0	15	0	0
52 MECH	9	300	30	213	0	0	30	0	0	213	0	0	0	0
WOC	8	7000	5	104	0	0	5	0	0	104	0	0	0	0
ATOC	7	5000	107	218	0	0	107	0	0	218	0	0	0	0
4ATAF	6	6000	245	178	0	0	245	0	0	178	0	0	0	0
23 ARM DIV	4	300	35	212	0	0	35	0	0	212	0	0	12	0
V CORPS	3	400	137	51	0	0	137	0	0	51	0	0	0	0
20 MECH	2	300	28	129	0	0	28	0	0	129	0	0	0	0
201 ACR	1	250	8	5	0	0	8	0	0	5	0	0	0	0

The effect on Corps Tac perceptions of Red forces is that there are 520 tanks with 389 reported losses.

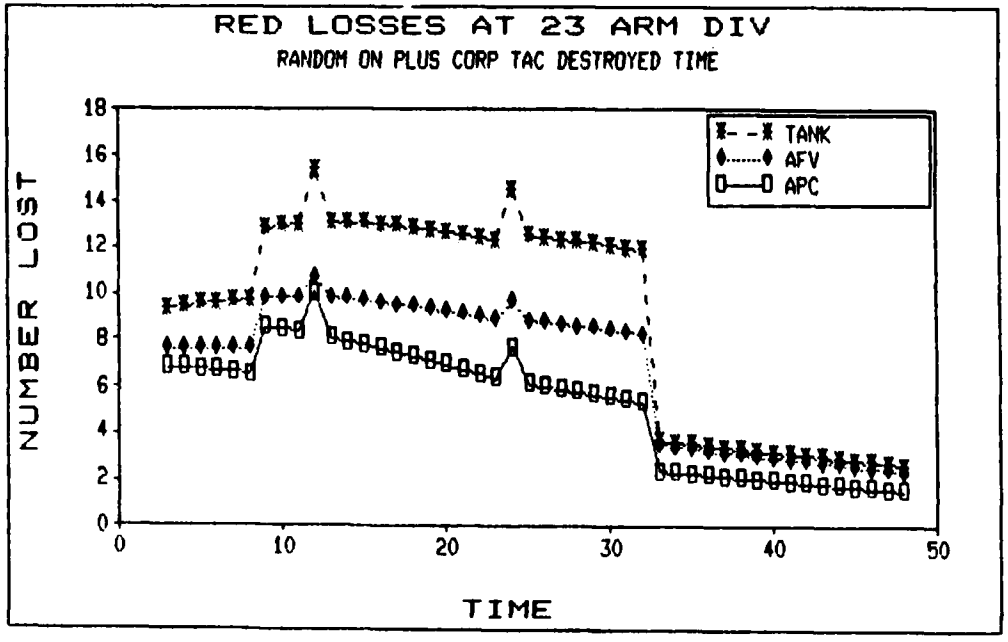
RANDOM ON PLUS CORP TAC DESTROYED TIME 4 - 20 9/4/85

COMBAT PERCEPTIONS BY V CORPS TAC OF 23 ARM DIV AT TIME 48
POSTURE BLUE 2

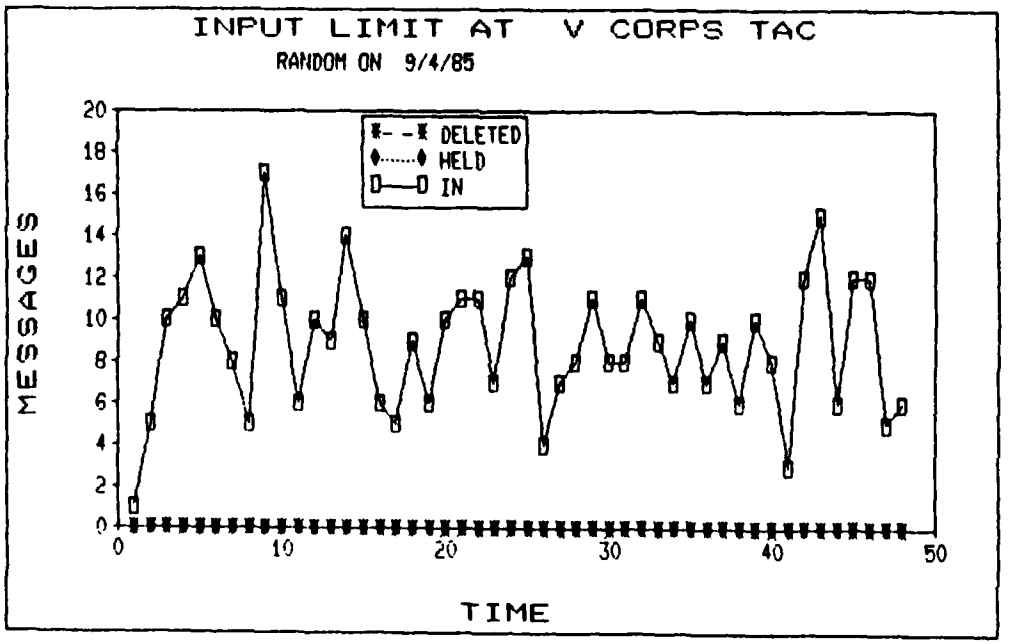
FOE UNIT	TYPE	POSTURE	TIME
127 TH MRD	325	2	1
17 TH TD	225	2	1
111 TH TD	225	2	1

UNIT APC	305	221
UNIT AFV	269	291
UNIT TANK	520	389
UNIT ATANK LT	830	220
UNIT ATANK HV	22	53
UNIT MORTAR	67	23
UNIT ARTILLERY	110	178
UNIT HELICOPTER	-69	69
UNIT AAA	47	1
UNIT SAM	312	3
UNIT CAS	-10	10

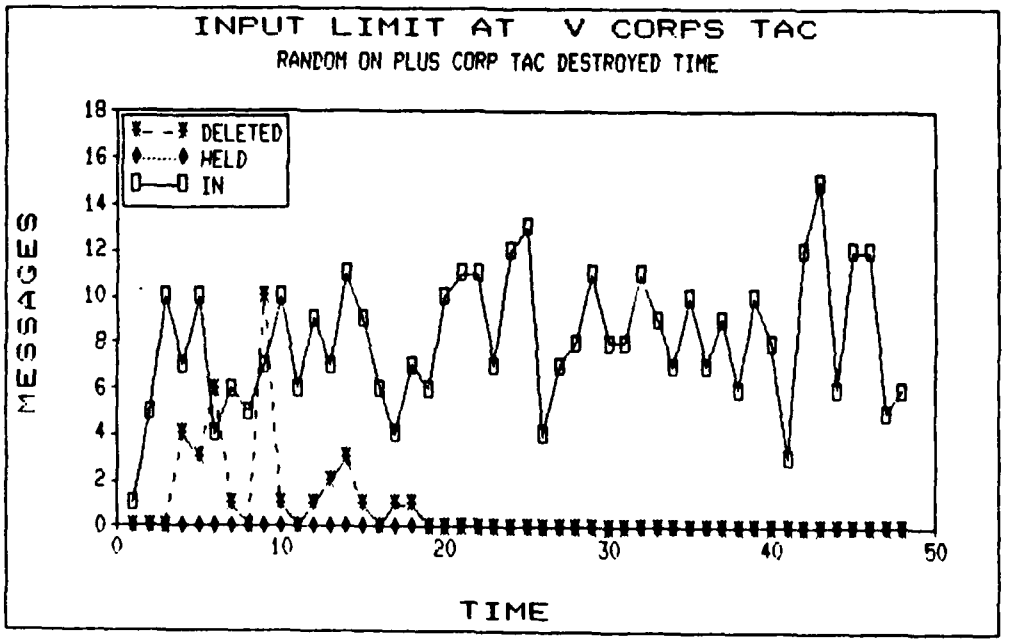
As a result of the unavailability of Corps Tac, the 23rd Armored Division does not receive all of the CAS/BAI sorties it received when the C^3 system was fully operational. These flights are reduced to two flights of six from the four that arrived for the base case.


RED LOSSES AT 23 ARM DIV
RANDOM ON PLUS CORP TAC DESTROYED TIME
NUMBER LOST
TIME
TANK
AFV
APC
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50

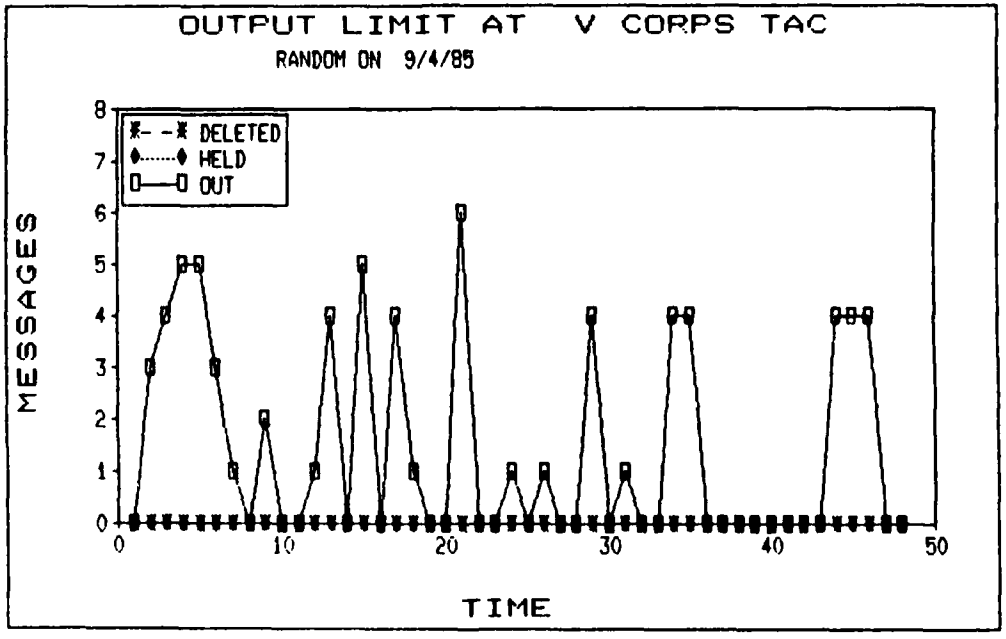
In order to examine the effect of the shut-down of Corps Tac on the message flow in more detail, it is necessary to consider the message flow as a time history. In the graph shown, the input flow of messages reaches a peak of 17 messages in time interval 9.


INPUT LIMIT AT V CORPS TAC
RANDOM ON 9/4/85
DELETED
HELD
IN
MESSAGES
TIME
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50

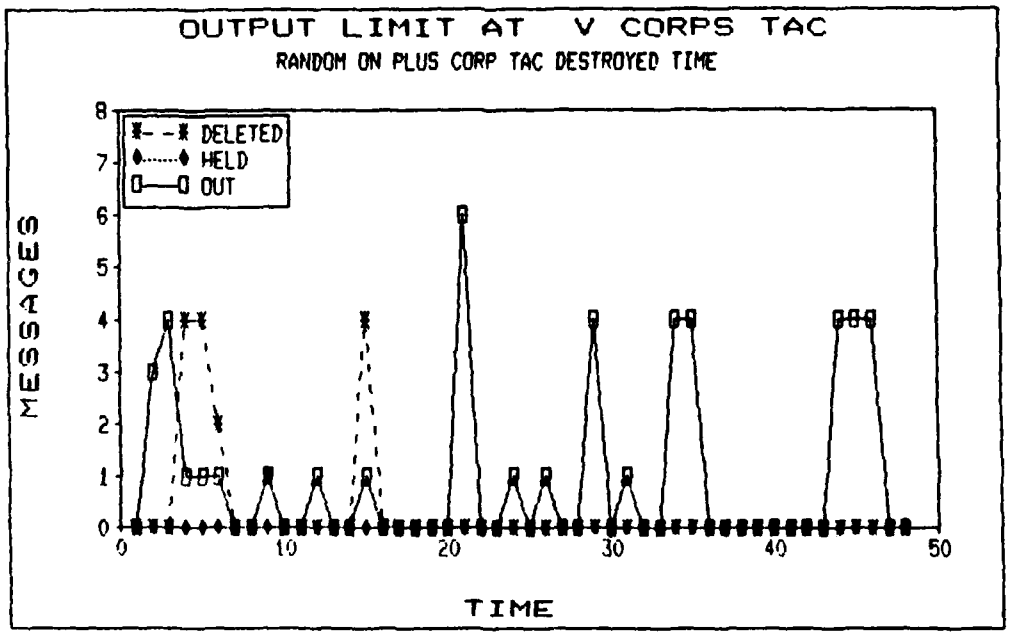
In comparison, the time history of the input messages with Corps Tac shut-down, the peak of messages at time interval 9 has been replaced with a peak of 10 messages deleted or lost at that time.


INPUT LIMIT AT V CORPS TAC
RANDOM ON PLUS CORP TAC DESTROYED TIME
DELETED
HELD
IN
MESSAGES
TIME
0
2
4
6
8
10
12
14
16
18
0
10
20
30
40
50

Similarly, an examination of the output flow of messages shows a peak at time interval 21 of six messages and a major flow of messages from time interval 3 to six. Three peaks occur in the range from time intervals 13 to 17.


OUTPUT LIMIT AT V CORPS TAC
RANDOM ON 9/4/85
DELETED
HELD
OUT
MESSAGES
TIME
0
10
20
30
40
50
1
2
3
4
5
6
7
8

When Corps Tac has shut down, the output flow pattern has changed considerably. The peak at time interval 21 remains, since this is after Corps Tac is back in full operation. During the period of shut-down, the period during which there was a major message flow has been replaced by a substantial deletion of messages. During the time intervals when the three peaks of message flow occurred, there is only one message sent at two of the former peaks, at one of these there are four messages deleted and the third peak has disappeared.


OUTPUT LIMIT AT V CORPS TAC
RANDOM ON PLUS CORP TAC DESTROYED TIME
DELETED
HELD
OUT
MESSAGES
TIME
0
1
2
3
4
5
6
7
8
0
10
20
30
40
50

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